Mapping and predicting benthic habitats in estuaries using towed underwater video

Thesis submitted by

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Certificate

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree.

I also certify that the thesis has been written by me and that any help that I have received in the research or preparation of the thesis, and all sources used, have been appropriately acknowledged.

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Abstract

With the global carbon crisis a matter of worldwide concern, efforts to preserve natural habitats that sequester carbon are of utmost importance. However, the processes which enable aquatic plants to survive and thrive are poorly known, as is the extent of their distribution and how they change over multiple scales. The aim of this research was to develop methodologies to help define the relationships between key benthic habitats and bio-physical variables and spatially predict their distribution and abundance within south-west Australian estuaries through towed underwater video. This thesis identified multiple non-destructive methods along with their strengths and limitations, to characterise benthic cover from underwater video, and highlighted optimal methods based on equipment, end goals, time and funding available. Additionally, I emphasize that no one method used in isolation was suitable for the analysis of underwater video from the shallow and turbid habitats from my study sites, but that a combination of methods was required for optimal characterisation.

This research is one of the first to model and spatially predict fine-resolution (5% intervals) percent cover of benthic habitats within estuaries from post-processed underwater video using biological and physical datasets with a state-of-the art machine learning method called ‘Random Forests’. This method is often used within terrestrial landscape ecology, but rarely within estuarine systems. Random Forests performed well with 79-90% variation explained by the models for each key benthic habitat and partial plots illustrated strong relationships between physical variables and biotic habitats. The most influential parameters driving biotic habitat distributions were longitude (19%), depth (13%), and latitude (11%), although this relationship varied between estuaries and on the degree of estuary connectivity to the sea (permanently-opened, artificially-opened and normally-closed). Predictive performance of key benthic habitat models was moderate to excellent and associated uncertainty maps of standard deviation of each model was highly variable in areas of habitat fragmentation.

Broad-resolution distributions of biotic habitats were found to be important in understanding local-scale physical processes. Seagrasses were the most common biotic habitat in five estuaries, although higher numbers of seagrass species occurred in the permanently-opened Leschenault Estuary (e.g. *Ruppia megacarpa*, *Halophila ovalis* and *Heterozostera tasmanica)*, while seasonally-opened (Wilson Inlet) and normally-closed

(Wellstead, Stokes and Beaufort) estuaries supported monospecific meadows of *R. megacarpa*. Red and green macroalgae had inverse latitudinal distributions, with red alga occurring in northern estuaries with higher amounts of seawater incursion and freshwater input. Green alga, especially green film alga were more prominent in the more stagnant, and normally-closed waters of the southern estuaries. Motile commercial fishery species such as crabs (*Portunus pelagicus*) were common in northern estuaries where access to marine influence was essential for their survival. Encrusting benthic polychaete worms such as *Ficopomatus enigmaticus* and the black mussel *Mytilus edulis* were found shallow sections of southern estuaries, which were able to tolerate extreme changes in water quality due to estuary bar closure, and often encrusting the hard substratum of submerged trees and rocks. This study demonstrated advances in modelling techniques of species abundances and distribution from underwater video and highlighted the importance of bio-physical relationships on spatial patterns of different seagrass species and other biotic habitats such as algae beds, polychaete mounds and mussel clumps in estuaries.

Estuarine habitats are at the forefront of climate change effects and experience rapid changes (within weeks to months) in their spatial distribution and abundance. I developed a real-time, rapid and accurate method to capture broad-resolution semi-quantitative (barren, low, moderate and high percent cover) changes in benthic habitats using underwater video, as traditional remote sensing methods such as aerial photography and satellite imagery can often take up to weeks and months to post-process for spatial habitat distribution. I tested the accuracy of two benthic habitat assessment protocols: the broad-resolution real-time classification protocol (called the "Rapid Benthic Assessment") against the fine-resolution post-processed habitat classification. I also tested the validation of the broad-resolution percent cover categories of seagrass from the RBA method using in situ samples of *R. megacarpa* and *H. ovalis*. The high correlation between the RBA and the fine-resolution method indicated that a high degree of detail and accuracy was retained by the RBA method. The visualisation of benthic habitats almost impossible to map through traditional remote sensing means was made possible through rapid data acquisition and visualisation from underwater video. This study demonstrated that real-time delineation of estuarine habitats allowed for rapid data analysis and representation within hours of data collection.

This research will enable resource management authorities to make informed decisions on monitoring benthic habitats which have global significance within estuarine systems from baseline habitat maps, supplement existing maps and understand how bio-physical attributes shape benthic habitat distributions.